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300 level.

$x^2\frac{d^2y}{dx^2} + x\frac{dy}{dx} + y = 0$

$x^2y'' + xy' + y = 0$

1st Product

x^2y''

$u = x^2 \quad u' = 2x \quad u'' = 2 \quad u''' = 0$

$v = y'' \quad v^{(n)} = y^{n+2}$.

$y^{nth} = u^{(n)}v + nu^{(n-1)}v' + \frac{n(n-1)u^{(n-2)}v''}{2!} + \frac{n(n-1)(n-2)u^{(n-3)}v^{(3)}}{3!}$

$y_2\ y^{n+2}.x^2 + nu^{(n-1)}.2x + \frac{n(n-1)u^{(n-2)}}{2\times1}.2 + \frac{n(n-1)(n-2)u^{(n-3)}}{3\times2\times1}.0$

$x^2y^{(n+2)} + 2nxy^{n+2-1} + n(n-1)y^{n+2-2}$

$x^2y^{(n+2)} + 2nxy^{n+1} + n(n-1)y^n$

2nd.

Product

xy'

$u = x \quad u' = 1 \quad u'' = 0$

$v = y' \quad v^{(n)} = y^{n+1}$

$= u^{(n)}v + nu^{(n-1)}v' + \frac{n(n-1)u^{(n-2)}}{2!}v''$

$= y^{n+1}.x + ny^{n+1-1}$

$= xy^{n+1} + ny^n$

y

$v = 1 \quad v' = 0$

$u = y \quad u^{(n)} = y^n$

$= u^{(n)}v + nu^{(n-1)}v'$

$= y^n.1$

$= x^2y^{(n+2)} + 2nxy^{n+1} + n(n-1)y^n + xy^{n+1} + ny^n + y^n$

$= x^2y^{(n+2)} + (2n+1)xy^{n+1} + y^n(n^2+1) = 0$

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(iii) $y = x^3 e^{4x}$

$u = x^3$ $\quad u = e^{4x}$

$u' = 3x^2$ $\quad u^{(n)} = 4^n e^{4x}$

$u'' = 6x$

$u''' = 6$

$u^{iv} = 0$

Using Leibnitz Theorem.

$y^{(n)} = u^{(n)} v + n u^{(n-1)} v' + \frac{n(n-1) u^{(n-2)} v''}{2!} + \frac{n(n-1)(n-2) u^{(n-3)} v'''}{3!}$

$+ 0$

$y^{(n)} = 4^n e^{4x} \cdot x^3 + n 4^{n-1} e^{4x} \cdot 3x^2 + \frac{n(n-1) 4^{n-2} e^{4x} \cdot 6x}{2 \times 1}$

$+ \frac{n(n-1)(n-2) 4^{(n-3)} e^{4x} \cdot 6}{3 \times 2 \times 1}$

$y^{(n)} = x^3 4^n e^{4x} + 3x^2 n 4^{(n-1)} e^{4x} + n(n-1) 4^{(n-2)} e^{4x} \cdot 3x + n(n-1)(n-2) 4^{(n-3)} e^{4x}$

$y^{(5)} = x^3 \cdot 4^5 e^{4x} + 3x^2 \cdot 5 \cdot 4^{(5-1)} e^{4x} + 5(5-1) 4^{(5-2)} e^{4x} \cdot 3x + 5(5-1)(5-2) 4^{(5-3)} e^{4x}$

$y^{(5)} = 1024 x^3 e^{4x} + 3840 x^2 e^{4x} + 3840 x e^{4x} + 960 e^{4x}$.

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$w^n = u^n v + o$

$w^n = 2 \cdot y^n$

$y^n = y^{(n+2)} - (y^{(n+1)}(2\cos(t)) + n2y^n) - 2y^n = 0$

$y^{(n+2)} = y^{(n+1)}(2\cos(t)) + n2y^n + 2y^n$

$y^{(n+2)} = (2\cos(t))y^{(n+1)} + 2y^n(n+1)$